911 – What´s your Emergency?

IPPC = Intergovernmental Panel on Climate Change;
RCP = Representative Concentration Pathways
ENSO = El Niño-Southern Oscillation
AMOC = Atlantic Meridional Overturning Circulation

TIPPING POINTS

A Climate Emergency

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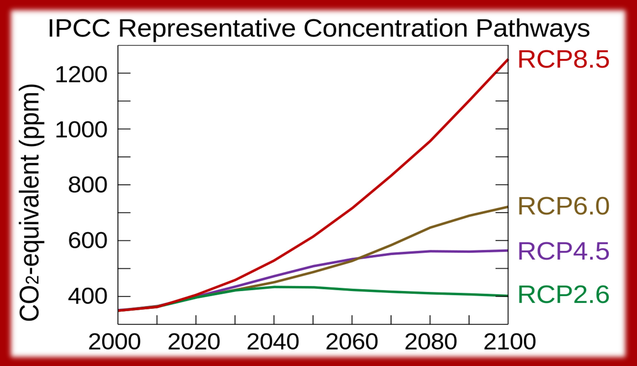
WHO?

- Impact on climate systems, ecosystems, social systems, economic systems, …
- overall stability of the earth system

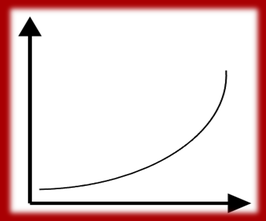
WHEN?

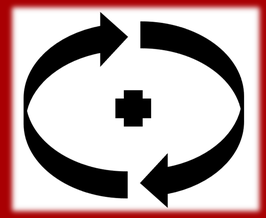
- Antropogenic climate change
  - increasing CO_2-concentration and global warming increases probability to reach tipping points
- Uncertainty about exact thresholds
  - Abprubt changes (few years)
  - Gradual transitions (millenia)
- Paris agreement 2015 set the goal to keep the long-term mean temperature rise below 2°C above pre-industrial level
  - Tipping points of Cryosphere and other systems could poissbily reach their critical threshold even in case of RCP2.6 (RCP2.6 is the only trajectory compatible with the Paris agreement)

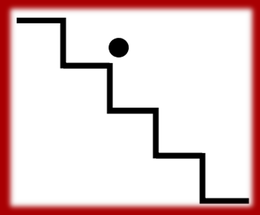


WHAT?

- Tipping points describe the critical threshold at which a small perturbation can ‚tip' a system into a qualitatively new state







Irreversible change

Positive feedbackloops

Domino-like chain reaction

Non-linear behaviour

- Interactions might produce a global tipping point
- Risk of „Hothouse Earth" where conditions for humans get undesirable - Steffen et al. 2018

WHERE?

- Tipping elements are large-scale components of the earth system that interact globally

Cryosphere

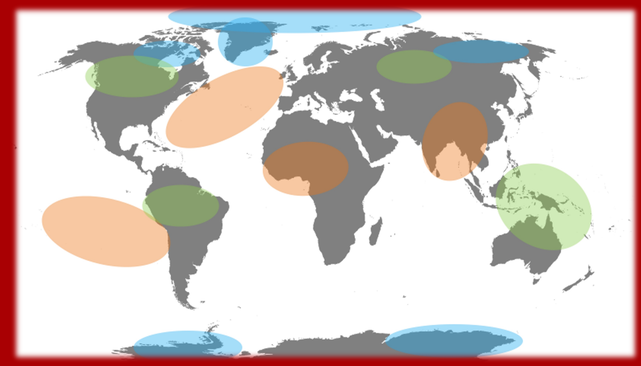
- Loss of Arctic sea ice
- Loss of Greenland ice sheet
- Thawing permafrost
- Loss of west and east Antarctic ice sheet

Circulation patterns

- Shift of west African monsoon
- Chaotic multistability of Asian monsoon
- Change in ENSO amplitude or frequency
- Destabilization of AMOC

Biosphere components

- Loss of boreal forests
- Loss of Amazonas rainforest
- Loss of tropical coral reefs



References:
Armstrong McKay, D.; Staal, A.; Abrams, J.; Winkelmann, R.; Sakschewski, B.; Loriani, S.; Fetzer, I.; Cornell, S.; Rockström, J.; Lenton, T. (2022): Exceeding 1.5°C global warming could trigger multiple climate tipping points. In: Science, Vol. 377, Issue. 6611.
Lenton, T.; Held, H.; Kriegler, E.; Hall, J.; Lucht, W.; Rahmsdorf, S.; Schellenhuber,, H. (2008): Tipping elements in the Earth´climate system. In: Proceedings of the national Academy of Science, Vol. 105, No. 6, pp. 1786-1793.
Lenton, T.; Rockström, J.; Gaffney, O.; Rahmsdorf, S.; Richardson, K.; Steffen, W.; Schellenhuber, H. (2019): Climate tipping points – too risky to bet against. In: Nature, Vol. 575, pp. 592-595.
Lenton, T.; Srmstrong McKay, D.; Loriani, S.; Abrams, S.; Lade, S.; Donges, J.; Milkoreit, M.; Powell, T.; Smith, S.; Zimm, C.; Buxton, J.; Bailey, E.; Laybourn, L.; Ghadiali, A.; Dyke, J. (2023): The Global Tipping Points Report 2023. Exeter.
Potsdam Institute for Climate Impact Research (n.d.): Kipppunkte im Klimasystem. Eine kurze Übersicht. Potsdam.
Steffen, W.; Rockström, J.; Richardson, K.; Lenton, T.; Folke, C.; Liverman, D.; Summerhayes, C.; Barnosky, A.; Cornell, S.; Crucifix, M.; Dongers, J.; Fetzer, I.; Lade, S.; Schaffer, M.; Winkelmann, R.; Schellenhuber, H. (2018): Trajectories of the Earth System in the Anthropocene. In: Proceedings of the National Academy of Sciences, Vol. 115, No. 33, pp. 8252-8259.
Umweltbundesamt für Mensch und Umwelt (2008): Kipp-Punkte im Klimasystem. Welche Gefharen drohen? Dessau.
Wunderling, N.; Donges, J.; Kurths, J.; Winkelmann, R. (2021): Interacting tipping elements increase risk of climate domino effects under global warming. In: Earth System Dynamics, Vol. 12, pp. 601-619.

Images:
Img. 1 Planet Earth: NASA (2015): Earth Western Hemisphere transparent background https://nl.wikipedia.org/wiki/Bestand:Earth_Western_Hemisphere_transparent_background.png
Img. 2 RCP trajectories: Efbrazil (2020): All forcing agents' atmospheric CO2-equivalent concentrations from the IPCC AR5 report https://de.wikipedia.org/wiki/Repräsentativer_Konzentrationspfad#/media/Datei:All_forcing_agents_CO2_equivalent_concentration.svg
Img. 3 Domino chain: Dmitriy83 (2019): Domino schwarz auf weißem Hintergrund https://www.istockphoto.com/de/foto/domino-schwarz-auf-weißem-hintergrund-drop-domino-effekt-hobbies-und-unterhaltung-gm1097715920-294787069?phrase=domino%2Beffect&searchscope=image%2Cfilm
Img. 4 Cryosphere: Ai Graphic (n.d.): Eisberg im das Ozean ai generiert Kostenloses Foto Eisberg Fotos auf Lager von Vecteezy
Img. 5 Circulation patterns: Pixabay (n.d.): Foto Von Brown Bare Tree Auf Brown Surface Während Des Tages https://www.pexels.com/de-de/foto/foto-von-brown-bare-tree-auf-brown-surface-wahrend-des-tages-60013/
Img. 6 Bisophere components: David Riaño Cortés (n.d.): Regenwald Umgeben Von Nebel https://www.pexels.com/de-de/foto/regenwald-umgeben-von-nebel-975771/
Img. 7 World map: Adapted from vemaps (n.d.): Grey Map of the World with Antarctica https://vemaps.com/world/wrld-14